



Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at <http://about.jstor.org/participate-jstor/individuals/early-journal-content>.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

NOTES ON SOME PROBLEMS OF ADAPTATION: 7. REGARDING THE PIGMENTATION OF STICHOPUS MCEBII.¹

W. J. CROZIER,

ZOOLOGICAL LABORATORY, RUTGERS COLLEGE.

The large holothurians of the genus *Stichopus*, which are quite abundant at Bermuda, live for the most part in fairly shallow water and upon grass-free bottoms of sandy mud. The majority of the individuals, but not all, are quite darkly pigmented. They are consequently open to the view of fishes and of other predaceous creatures, their coloration being in the great majority of cases very far from "concealing" in character. I was curious to learn if this lack of concealment was in any way related to size, or to the presence of some repugnatorial property. These holothurians do not possess Cuvierian organs.²

About 70 per cent. of the individuals are dorsally of a deep brown or even blackish hue, some 20 per cent. being light brown, with a distinctly yellowish cast, and the remaining 10 per cent. very pale brown with a pinkish shade. About 75 per cent. of the two kinds of lighter-colored specimens show a series of circular dark blotches, located at the bases of the scattered podia. A small proportion are irregularly mottled or blotched with areas of dark pigmentation. The pale spotted individuals are in many instances very difficult to detect, especially if located among algæ and corals on an inclined shore; on a bare mud bottom they are more easily seen. The amount of pigment in the integument bears no definite relation to age (size).

¹ Contributions from the Bermuda Biological Station for Research, No. 133.

² I have vainly sought for instances in which the well-developed Cuvierian organs of *Holothuria captiva* (Crozier, '15) might be seen in action (cf. Cuénot, '98). This species sometimes lives, under stones, in association with the large annelid *Hermodice carunculata*, which is armed with powerful groups of long, sharp setæ; but I have never seen evidence of disturbance of the holothurian by the annelid. The tubes of the Cuvierian organ when discharged in air and received on filter paper (or on the tongue) are never acid in reaction; apparently their sole utility is in connection with their tensile strength and adhesive power.

In view of the absolute lack of any concealing behavior practiced by these creatures, I tried at various times to feed pieces of the skin to fishes ("squirrels," yellow grunts, gray snappers, and other common shore forms, including the hamlet). Such trials were invariable unsuccessful, the flesh being refused. And, as Minchin ('92) long ago found, the intestine and respiratory trees are likewise rejected as food.

It is of interest to note that, in spite of such evidence of "unpalatability,"—which may perhaps be supplemented from Bartsch's ('17) account of the use of "holothurians" by the natives of Guam in driving *Octopus* from its "nests,"—holothurians are nevertheless occasionally seen in the rôle of hosts for erratic ectoparasites, which in some instances eat from their skin. Chatton ('09) found an ascidian attached to and growing on the integument of *Holothuria*, and I have seen a young actinian (*Condylactis*) firmly affixed to the integument of a *Stichopus*. Quite apart from such molluscan forms as *Stylifer*, one species of which I have found in considerable numbers on *S. mæbii*, I have records of an annelid (an unidentified species of *Odontosyllis*) and of a polyclad worm, *Leptoplana*, feeding on the skin of *Holothuria surinamensis*; the gut of the worm was in each of these cases filled with the bright green integumentary pigment of the host. So that it is difficult to postulate for these animals the possession of any generalized repellent secretion. Plate ('16), also, has described a polynoid and a crab, both homochromic in coloration, living upon *Holothuria atra*.

On the other hand, *Holothuria surinamensis* has on several occasions been found bearing clear evidence of injury. One specimen was picked up, lying in the open on a sandy bottom with a shallow gouge cut along the whole length of the body; in all probability it had been nipped by a crab, perhaps *Callinectes*. Later, three others were obtained, all injured in a similar way. In the absence of some repellent "flavor," it is difficult to understand why the holothurians, once bitten into in this way, should have been dropped. This particular species, as I have said, is devoid of Cuvierian organs, and in the mangrove creeks where it notably abounds it comes to the surface only at night, being

buried during the day about the roots of sea weeds. Its skin, incidentally, is covered by a slimy coating of mud-particles, tending to give it a concealing hue; whereas *H. captiva*, well equipped with Cuvierian organs, but living under stones, is of a brilliant dark green color, unobscured with mud.

In feeding tests, the flesh of *H. surinamensis* was rejected as vigorously as was that of *Stichopus*.

It seems on the whole quite possible that some repugnatorial property is present in the secretions of the holothurian skin. The repellent power of the skin of the nudibranch *Chromodoris zebra* has been amply demonstrated (Crozier, '16, and subsequent work), yet I have found ostracods (*Cypris*) creeping freely over its skin; and while the blue-black *Ascidia atra* is rejected, whole or in fragments, by fishes I have tested, certain polyclads, nevertheless, feed freely on its surface (Crozier, '17). It is not inconceivable that the slimy quality of the holothurian flesh, particularly as developed when the body wall is cut, is in itself a sufficient repellent. I have never succeeded in inducing aquarium fishes to swallow swollen pieces of gelatin, although in this case a specific repellent action seems improbable.

The adult *Stichopus* is, at all events, practically immune from the grosser kinds of attack. The only dead or injured specimens I have seen were killed by heavy rain-fall on shallow shores at low tide, or else by the sun when left by the tide on an exposed beach. The flesh of these animals is not an acceptable article of diet to fishes or to octopus, and whether this immunity be due in part to specific repugnatorial secretions, for which there is some evidence, or to some physical property of the flesh, or to the large size of the individuals, the feature which for present purposes I regard as significant is this: although efficiently protected, as it seems to be, the coloration of the species exhibits a wide range of variation, such that in some instances it might be thought "warning," in others decidedly "concealing." The conclusion is difficult to avoid, that the "conspicuous" type of pigmentation is only associated with immunity from attack in a secondary, and in a sense an accidental, manner. The flesh of the paler, spotted, and as I believe, on the whole better concealed,

individuals, is no more acceptable as food than that of the blackish specimens. The different degrees of pigmentation are determined, so far as one may judge, by quantitative differences in the capacity for producing the single type of pigmentary substance concerned. So far as available evidence permits one to say, it is as reasonable to hold that the immunity of *Stichopus*, however achieved, permits its pigment-forming power to develop unhampered by selective restraint, as to believe that a kind of "warning" coloration is being elaborated selectively. In this respect the diverse types of coloration found in the efficiently protected snail *Onchidium* (Crozier and Arey, '19) provide an interesting parallel. And in *Chromodoris* (Crozier, '19), as I shall subsequently describe at length, the evidence is much more decisively of the same import. Questions of this sort, particularly as concerned with the matter of so-called "warning" coloration, have been, in my belief, on the whole so inadequately dealt with that even partially complete observations seem worthy of presentation.

Summary.—The coloration of *Stichopus mæbii* is quite variable, in some individuals probably of a concealing tendency, in others, the majority, of a sort which makes these animals in nature pronouncedly conspicuous. Perhaps conditioned by the bulk of the animals, possibly by the presence of a repugnant quality of the flesh, such as leads to the rejection by fishes of fragments offered as food, a decided immunity from gross attack is, at all events, achieved. There is no more reason to regard the conspicuous type of pigmentation as a warning agent than there is to consider it the unchecked expression of innate metabolic activities.

CITATIONS.

Bartsch, P.

- '17 Pirates of the Deep—Stories of the Squid and Octopus. Ann. Rept. Smiths. Instn. for 1915-16; Append., pp. 347-375.

Chatton, E.

- '09 Une ascidie fixée dans la peau d'*Holothuria tubulosa* Gm. Bull. Soc. Zoöl. Fr., T. 34, pp. 25-27.

Crozier, W. J.

- '15 A Note on the Physiology of the Cuvierian organs of *Holothuria captiva* Ludw. Amer. Jour. Physiol., Vol. 36, pp. 196-202.
'16 On the Immunity Coloration of Some Nudibranchs. Proc. Nat. Acad. Sci., Vol. 2, pp. 672-675.

'17 On the Pigmentation of a Polyclad. Proc. Amer. Acad. Arts and Sci., Vol. 52, pp. 725-730.

'19 Further Contributions upon the Natural History of *Chromodoris zebra*: the Question of Adaptive Coloration. Anat. Rec., Vol. 15, p. 349.

Crozier, W. J., and Arey, L. B.

'19 *Onchidium* and the Question of Adaptive Coloration. Amer. Nat., Vol. 53, pp. 415-430.

Cuénot, L.

'98 Les moyens de défense chez les animaux. Bull. Soc. Zool. Fr., Tom. 23, pp. 37-58.

Minchin, E. A.

'92 Notes on the Cuvierian Organs of *Holothuria nigra*. Ann. Mag. Nat. Hist., ser. 6, Vol. 10, pp. 273-284, Pl. 17.

Plate, L.

'16 Fauna Ceylanica. II. Übersicht über biologische Studien auf Ceylon. Jena. Zeits. Naturw., Bd. 54, pp. 1-42.